Sandia National Laboratories

Environmental Program

Cross Borehole Electromagnetic Imaging

Technology Need

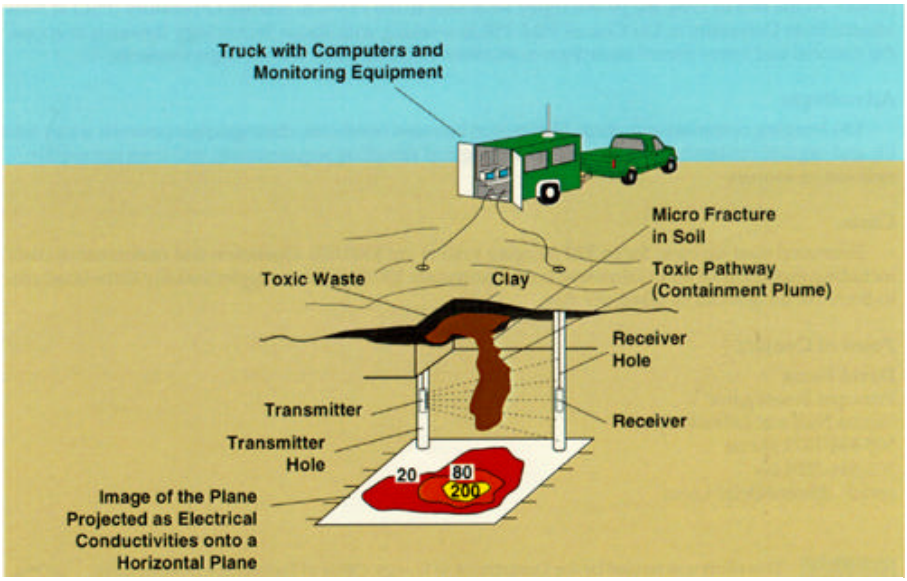
In landfills containing metallic waste forms, the contrasts in electrical properties enhance the effectiveness of several electrical and electromagnetic methods for site characterization and monitoring. For the problem of source and plume detection at these landfill sites, the continuous wave and pulsed radar systems provide a means to image the subsurface for targets that may be uniquely suited for the method.

Objective

Cross Borehole Electromagnetic Imaging (EM Imaging) was designed to characterize waste sites and monitor plume migrations.

Project Description

EM Imaging is based on the radio imaging method. This continuous wave form technique measures the strength and timing (amplitude and phase) relationship of a transmitted waveform (15 million cycles per second) as the signal travels from borehole-to-borehole or borehole-to-surface. The imaging system consists of a transmitter and receiver, 2 inches in diameter and 6-12 feet in length. The transmitter and receiver are placed in separate boreholes and lowered by fiber optic cables, or the transmitter is placed in one borehole and the receiver on the ground surface. The tomographic data is collected in a series of ray path fans (a set of received signals that look like a fan). This is similar to medical tomographic imaging which shows a two or three dimensional image of a body structure constructed by computer from a series of flat cross-sectional images made along a certain axis. The transmitter and receiver are lowered to a station location and a measurement is made. The receiver is moved to the next location (approximately 2.5 to 5 feet apart) and another measurement is made. The receiver is again moved, and the measurements are made repeatedly until the ray path fan is completed. Transmitter and receiver calibrations are taken at each station (calibration



Electromagnetic Imaging System

values are used to normalize the data). The resolution (smallest object imaged) is 1/20 of the distance between the transmitter and the receiver. At Sandia National Laboratories' (SNL's) Chemical Waste Landfill (CWL), the resolution is approximately 1.5 feet. The distribution of electrical conductivity between boreholes can be reconstructed From the repeated and overlapping measurements of amplitude and phase between boreholes. These properties are sensitive to changes in moisture content, permeability, and water chemistry and will characterize changes in the landfill system and the zone between the landfill and the water table.

During 1992, the CWL at SNL was imaged. During 1993, borehole-to-borehole surveys of the 60s Pits (waste disposal pits) at the CWL were also completed. These surveys delineated with three-foot resolution the chromic acid plume and subsurface geology at the unlined chromic acid pit and mapped a series of disposal trenches at the 60s Pits. During 1994, a 400 foot long borehole-to-surface tomographic survey of the Kirtland Air Force Base's RB-11 landfill was finished. The survey defined the outline of numerous disposal trenches and buried objects. This survey also detected a storm-caused infiltration event.

Technology Transfer

Transfer of this technology has been successful. RIMtech, Inc., and Raytheon Nevada Services have provided contract services to the Department of Energy remediation projects at Fernald, Rocky Flats, and the Idaho National Engineering Laboratory based on the imaging technologies demonstrated in this project. At the end of 1994, the patent rights were sold to the Physical Science Laboratory (PSL) at New Mexico State University in Las Cruces, NM. PSL is working with Raton Technology Research to access the national and international environment markets. PSL also plans further improvements.

Advantages

EM Imaging optimizes sampling, fills in gaps between boreholes, distinguishes between water soluble and organic contamination, minimizes drilling and sampling requirements, and does not require radioactive sources.

Costs

Estimated start-up costs for an EM Imaging system are $300,000. Operation and maintenance costs including mobilization and manpower is approximately $5000 per day. Approximately three borehole-to-borehole images can be taken per day.

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